ECONOMIC EVALUATION OF ENVIRONMENTAL IMPACTS: TECHNIQUES, RESULTS AND INSTITUTIONAL EXPERIENCE

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1. Introduction

The purpose of this paper is to identify the role that economic analysis can play in environmental policy-making, taking various international experiences by way of illustration.

To begin with, it is acknowledged that environmental issues may be viewed from various perspectives. Traditionally, environmental problems have nearly always been viewed from a scientific or political perspective, while scant attention has been paid to their economic dimension. Neglecting the economic perspective has often resulted in very expensive policies relative to the benefits obtained. Here it will be argued that this neglect has had negative consequences not only for the economy but also for the environment itself.

This review of international experiences starts with the American experience, since the US is a country which has pioneered the application

of economic analysis to environmental problems. Next, the growing role of economics in the EU will be considered, with particular reference to the UK experiences, where there has been much progress in the inclusion of the economic perspective during the last decade.

Finally, this paper identifies the legal, political and institutional mechanisms which have helped to increase the role of economics in environmental debates and might be of interest for Galicia or Spain.

2. Review of alternative models for environmental decision taking

In order to better understand how environmental policies have traditionally been devised, a characterisation of four models for environmental decision taking is given,

- Environmental model
- Scientific model
- Political model
- Economic model

These models are presented as caricatures in order to emphasize the differences between them. Moreover, it is acknowledged that, in fact, environmental decisions do not follow a single model, but various criteria may, and must, influence in particular circumstances. For this reason, even though the economic perspective makes a very valuable contribution to the environmental debate, it will never entirely replace the various alternative approaches.

2.1. The environmentalist model

The environmentalist model (green, ecological) may be characterised by its extreme philosophical position regarding the environment. Although this extreme environmental position represents only a minority viewpoint in most countries, the political pressure that such minorities exert is nonetheless

important and their arguments also play a significant role in the public debate about environmental policies.

Although the environmentalist viewpoint encompasses a wide range of different view, some typical elements of this philosophy can be identified.

- First, environmentalists place particular emphasis on the unique character of the environment and so, and use this to argue that the decision taking criteria should not be the same as those applied in other spheres: “the environment is different and thus deserves special treatment”. For this reason, environmentalists often vehemently oppose the application of economic analysis to environmental issues.
- Second, some environmentalists maintain that nature (and in particular, certain animal species) have certain rights that human beings should respect.
- Third, environmentalists tend to stress the fact that pollution can produce irreversible damage, which should consequently be avoided.

To conclude, this philosophical position leads to very strong conclusions concerning the interaction between man and his environment: pollution and human interference with ecosystems should be avoided at all cost.

2.2. The scientific model

The environmental processes which connect human activity, environmental pollution, human health outcomes and ultimate impact on ecosystems may be extremely complex and difficult to understand. A precise knowledge of all these interconnections provides the essential basis for any environmental policy, irrespective of the ultimate model of environmental decision taking.

However, what will here be described as the “scientific model” goes somewhat further than this. Specifically, according to this model, scientific data is the only information required to design good environmental policies. According to this view, decisions should be taken in the following way.

- Where there is good knowledge of the dose-response relationship between pollution and environmental impact, it is usually possible to identify the threshold above which pollution starts to produce harmful impacts (this threshold usually corresponds to the assimilative capacity of the environment or the human body). In these cases, the scientific model advises maintaining pollution levels beneath this threshold.

- Notwithstanding, there exist many areas where the knowledge of dose-response relationships continues to be deficient. In these cases, the scientific model proposes a precautionary attitude. In general, this means acting as if there was a harmful effect until there is evidence on the contrary.

2.3. The political model

As a general rule, environmental policies inflict costs on some social groups while bringing benefits for others. For example, a regulation that requires the modification of vehicles in order to reduce exhaust levels in the urban environment inflicts expenses upon car owners while bringing benefits for pedestrians. In other words, environmental regulations have the effect of redistributing wellbeing between these two groups. Therefore, it is to be expected that the "winners" should be in favour of the regulation and the "losers" should be against it. In a political process, it is probable that the outcome of this conflict reflects the relative political power of both groups.

An important problem associated with this political model of environmental decision making, arises from the fact that due to the very nature of environmental issues it is often the case that either the winners or the losers from an environmental policy lack a political voice. This situation can arise in any of the following circumstances.

- First, if the group that wins or loses is a large and diffuse population, even though the aggregate costs or benefits they face may be substantial, the impact on each individual is so small in relation to the costs of organizing themselves as a political group, that there is no incentive for anyone to enter into the political arena.

- Second, if the "winners" or the "losers" are outside the country where the pollution takes place, they will also be excluded from the political process unless some international negotiation can be arranged.

- Third, if environmental impacts are long-term, it is possible that the main "winners" or "losers" are not even born at the time when decisions are being taken.

2.4. The economic model

Given the deficiencies identified with the political model, the economic model advocates the comparison of costs and benefits of environmental policies for all affected parties (Hahn, 1999b; Pearce, 2000). While benefits exceed costs, a policy may be considered desirable in the sense that the "winners" could theoretically compensate the "losers" and still be better off than before the implementation of the policy. In this way, the economic model intends to take into account the interests of individuals who, for various reasons, cannot be represented by the political system.

The economic model departs from the premise that environmental policies are costly; and are funded from scarce resources which might be allocated for other purposes. Consequently, it is important to question whether the results attained by these policies are worth the resources devoted to them. In other words, the principal aim of the economic model is to ensure the efficiency of environmental policies.

This central priority of the economic model leads to two basic principles.

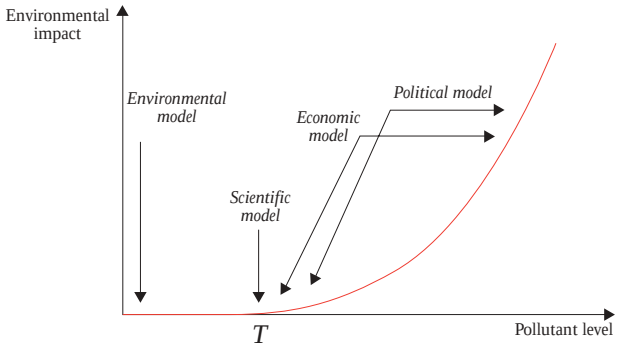
- First, an environmental regulation should only be adopted if the benefits are higher than the associated costs.

- Second, policy makers should always strive for the least cost means to achieve any given environmental objective.

2.5. Comparison between models

Figure 1 is intended to clarify the precise differences between the various models by means of an example. The horizontal axis represents the level of pollution, while the vertical axis represents the corresponding level of environmental impact. The curve shows the relation between these two concepts.

Figure 1
Contrast between alternative models of environmental decision making



As can be seen in Figure 1, up to T the pollution level is within the assimilative limits of the environment. However, from T onwards the environmental impacts of pollution become increasingly large. In this framework, the conclusions reached by the various models of environmental decision making can be characterized in the following way.

- *Environmentalist model.* This model ignores the relation between pollution and environmental impact, and advocates eliminating pollution altogether.
- *Scientific model.* This model argues that the pollution level should always be kept below T.
- *Political model.* This model is willing to tolerate pollution levels higher than T, but only if the "losers" from the pollution control measures enjoy greater political influence than the "winners".
- *Economic model.* This model argues for pollution levels higher than T only if it can be shown that the cost of the resulting environmental impact is lower than that resulting from the adoption of pollution control measures.

3. Instruments for Economic Analysis of the Environment

The economic model of environmental decision making offers a series of instruments to analyse, support and clarify the process of policy formulation. The principal ones among them would be the following (OECD, 1997).

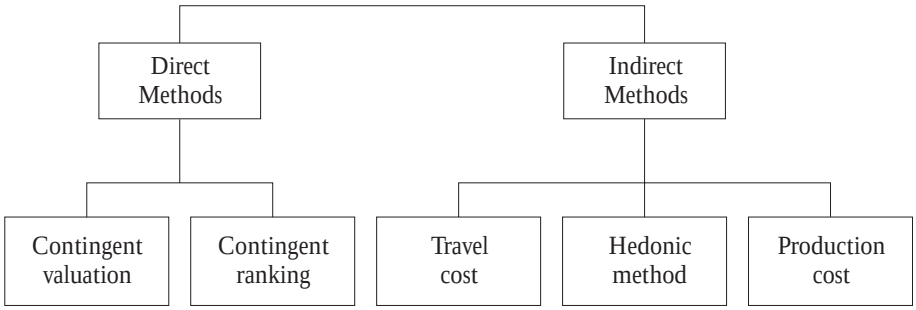
- *Cost estimation*. Which simply consists of adding up all costs arising from a given environmental policy. This helps to provide a complete picture of the economic burden of a policy, and permits comparisons with other policies.
- *Cost-effectiveness analysis.* This involves comparing the costs of a policy with the physical impacts expected. In this way, unitary costs for each type of physical impact can be obtained (for example, cost of each case of respiratory disease avoided). With such information it is possible to identify the most efficient measures for achieving a particular outcome.
- *Cost-benefit analysis.* This involves comparing the costs of a policy with its benefits. Benefits must be expressed in monetary terms in order to permit a direct comparison with costs. This analysis makes it possible to verify if benefits exceed costs, as well as to compare the benefit per unit of expenditure across alternative policies.
- *Risk analysis.* This aims to estimate the risks faced with and without implementing a particular environmental policy.

3.1. Methods of economic valuation

The application of the cost-benefit analysis to environmental decisions depends on the ability to place an economic value on the impacts of human activity on the environment (water, air, ecosystems) and human health (diseases and deaths avoided). For more than thirty years economists have been developing and refining methodologies which permit this kind of valuation, so that a vast literature on the subject now exists.

As can be seen in Figure 2, there exist two “methodological families” for performing economic valuation of environmental impacts.

Figure 2
Methodologies for valuing environmental benefits



- *Direct methods:* these use questionnaires to directly ask people what they are willing to pay for the preservation of some environmental resource, the avoidance of some health problem or the reduction of their own risk of death.
- *Indirect methods:* these methods study the actual economic behaviour of people in the market place and use this to infer an economic value for environmental resources.

The three main methods which have been developed are the following.

(1) Travel cost models: This methodology is based on the idea that the more people value something the farther they are willing to go in order to get it. This principle can be applied to value national parks and sites of natural beauty by studying the costs people are willing to incur in order to visit these places, it becomes possible to estimate the benefit they obtain from their visits in monetary terms.

(2) Hedonic models: This methodology is based on the observation that environmental conditions, even though not traded in market, have an appreciable impact on other goods which are traded in the market. For example, a house on a site with clean air, a good view and a tranquil atmosphere is more expensive than an identical house in the immediate vicinity of a motorway. The difference in value between these two identical houses provides an indication of the benefit resulting from good environmental conditions.

(3) *Contingent valuation method:* Contrary to the above methodologies, contingent valuation is not based on real market behaviour. Instead, it uses a questionnaire to present a scenario in which the level of environmental quality somehow changes (for example, improving air quality, cleaner beaches, or the extension of national parks). It is important for this scenario to be as realistic as possible. The questionnaire asks people their willingness to pay in order to obtain the mentioned improvement, whether by means of a tax increase or in terms of a fee that would have to be paid to enter the park or beach. The assumption is that people's willingness to pay for the proposed environmental improvement indicates the benefit they obtain. The contingent valuation method has been subject to criticism due to the fact that it is carried out in a completely hypothetical context. Therefore it is certain whether people would be actually willing to pay what they declare to be willing to pay. In this regard, there is a risk that the contingent valuation method may overestimate the monetary value of the environmental improvement.

Chart 1 presents the results from a study which compares the results from a series of contingent valuation studies in the UK with actual gifts received by non-governmental environmental organisations for the same natural resources (Foster, Bateman and Harley, 1997). This study shows that the value of the average gift is quite similar to the average value resulting from the contingent valuation studies. Notwithstanding, the percentage of the population willing to contribute to nature preservation is significantly higher in a hypothetical situation than is the case in real fund-raising appeals.

Chart 1
Comparison between real donation and contingent valuations

	Average contribution		Percentage contributing	
Natural resource	Donation	CV	Donation	CV
Woods	£ 16.82	£ 11.92	6%	67%
Heathland	£ 18.45	£ 26.06	6%	92%
Wetland	£ 20.14	£ 21.53	7%	20%

Source: Foster, Bateman and Harley, 1997

3.2. Valuation of human life

Perhaps the most controversial issue arising in environmental cost-benefit analysis is the application of monetary values to health and human life itself. Therefore, it is very important to have a clear understanding of exactly what is meant by "valuing human life". In fact, what is actually valued is not life itself, but rather small reductions in the risk of death. These values of risk reduction are usually scaled-up by the inverse of the risk level, and are then known as 'statistical values of life'. Thus, for example, if the value of a reduction in the risk of death of 1 in 1,000 is $10,000, then the value of statistical life is $10,000,000 (=10,000/0.001)

There are many human activities, which though freely undertaken significantly increase the risk of premature death. In particular, some professions (for example, construction and mining) involve a death risk significantly higher than the norm. Economists have compared the wages in these professions with those in other professions which require the same level of qualifications but which entail substantially lower levels of risk. They have found that wages in risky professions include a wage premium in order to compensate for the higher risk level to which their workers are exposed.

Chart 2 presents the results from various UK labour market surveys that, in general, show an implicit value of human life well above US$ 1 m. It is worth noting that the results obtained from hedonic models are very consistent with those from contingent valuation studies on the same topic.

Chart 2
Comparison between values of human life obtained by different methods

Risk	Year	Country	Value
Labour market risk	1991	Japan	$ 7,5 m
Hedonic model: wage differentials	1991	Australia	$ 6,3 m
according to work risk	1991	USA	$ 0,8 m
Risk of trafic	1998	UK	$ 3,8 m
Contingent valuation: willingness to pay	1991	USA	$ 9,7 m
avoid an accident	1991	New Zealand	$ 1,2 m

Source: OECD, 1997

3.3. Cost-effectiveness analysis

Chart 3 presents a sample of the results from a cost-effectiveness study of various US regulations designed to protect human life. The total costs of complying with each regulation and the resulting number of lives saved were estimated in each case. In this way, it is possible to obtain the unit cost for each life saved. This type of analysis reveals the very wide variation in the costs of saving lives by various alternative means; safety belts and safety measures in building areas are found to be the most cost-effective measures. In general, the cost of saving a human life by means of environmental regulations is found to be very much more costly.

An important consequence of this result is that redistributing resources from high unit cost programmes to those with lower unit cost could significantly increase the number of saved lives with the same economic resources. It has been estimated that this type of reallocation of resources could save 60,000 lives each year in the US.

In another similar study, Hahn (1996) finds that the cost per life saved by regulatory measures varies between US$10,000 and US $36 bn, with an average of US$6m. Hahn also shows that the average cost per life saved varies between US$50m for environmental regulations, US$15m for health regulations, and US$1m for safety regulations.

Chart 3
Cost per life saved by means of various different regulations

Focus of regulation	Cost per life saved
Safety belts	$ 0,3 m
Safety on building sites	$ 1,4 m
Control of agricultural dust	$ 5,3 m
Control of arsenic in industrial processes	$ 26,5 m
Control of dust in uranium mines	$ 53,0 m
Control of asbestos	$ 104,2 m
Radioactive issues	$ 210,0 m
Burial of solid waste	$ 3,500 m

Source: OECD, 1997

3.4. Risk analysis

The analysis of risks associated with various environmental problems can provide a useful input to environmental policy design. Chart 4 presents the results from a study which identifies equivalencies between environmental risks and risks freely assumed in everyday life. All activities identified in the chart bring about the same increase in the risk of premature death of about one in a million.

Chart 4
Comparison of activities with similar risk levels

All these activities increase death risk in $1x10^{-6}$
- Smoking 1,4 cigarettes
- Drinking half a litre of wine
- Travelling 250 km by car
- Travelling 6.000 km by plane
- Having a chest x-ray
- Breathing New York air for 48 hours
- Drinking Miami drinking water for a year
- Living by a nuclear plant for 5 years
- Living by a PVC factory for 20 years

Source: OECD, 19977

The first five risks identified relate to familiar every day activities (smoking, drinking wine, travelling, having an x-ray), while the last four activities are environmental policy related. It is particularly striking that living for many years in the vicinity of industrial installations such as a nuclear plant or a PVC factory does not result in greater risk than smoking some cigarettes or drinking a few glasses of wine.

4. Experience with the economic model: the US

Since the 1970s, US presidents have shown a growing interest in scrutinising and evaluating the regulations issued by the various federal agencies for social regulation.

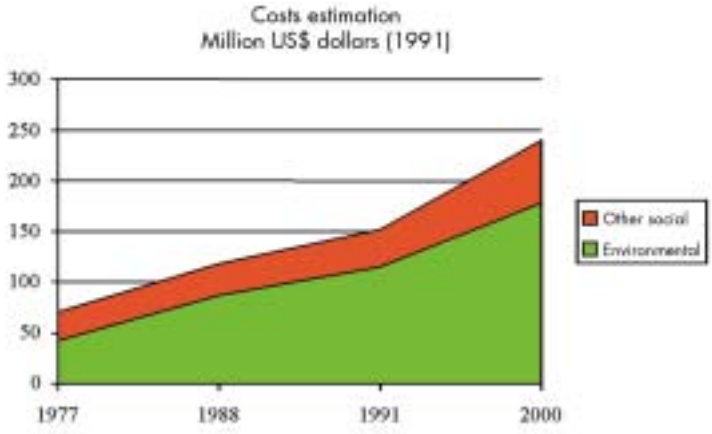
President Reagan gave particular impetus to this tendency by issuing Executive Order 12291, at the outset of his presidency in 1981. This resolution establishes the obligation to carry out a cost-benefit analysis for all regulations whose costs exceed the threshold of US$100 m (Morgenstern, 1997).

However, the executive order did not in fact lead to the universal application of cost-benefit analysis. The reason was that in some cases the very statutes that established the regulations forbade this type of analysis, while in other cases its application was impeded by contrary judicial rulings.

There are two basic explanations for the mounting political pressure to submit social regulation to economic scrutiny.

First, regulation was increasingly being considered as a form of “hidden taxation”... As a general rule, governments have two ways to controlling economic resources. The first is to collect taxes to finance public expenditure directly. The second is to issue regulations that compel other economic agents to spend resources in pursuit of social objectives. While tax policy is relatively transparent, regulatory policy brings about costs that are rather indirect and, therefore, less conspicuous. The acknowledgement of this fact has resulted in pressure to make governments as accountable for regulatory burdens as they are for tax burdens.

Figure 3
Historical trend in the cost of social regulations in the US



Source: Guasch & Haln, 1998.

Second, there was gradually accumulating evidence about the high and increasing cost of complying with social and, particularly, environmental regulations. The Figure 3 above shows the historical trend. Between 1977 and 2000, total costs have gone up more than threefold. A recent study estimated the total costs of US environmental regulations in 1996 at US$ 162 bn (Hahn & Litan, 2000). This amount is equivalent to two thirds of the federal budget (excluding national defence). Most of the costs of social regulation in the US can be attributed to environmental regulations, which, currently represent about 75 % of the total. The remaining 25 % correspondes to health and safety regulations applicable to places of work, roads, mines and consumer goods.

4.1. Cost-benefit analysis of federal environmental regulations

In an attempt to formalise and systematize the cost-benefit analysis required by Executive Order 12291, a bill was passed in 1997 compelling the Office of Management and Budget to present Congress with an annual report detailing the costs and benefits of federal regulations. The report is not limited to social and environmental regulations, but also considers economic and process regulations.

Since then, three such annual reports have been published corresponding to the years 1997, 1998 and 1999. These reports present aggregate cost-benefit data for all federal regulations grouped by areas but also provide cost-benefit information on individual regulations

Although the recent OMB reports represent a significant improvement with respect to past practice, they have nonetheless been criticised by the academic community, in particular, for the following reasons.

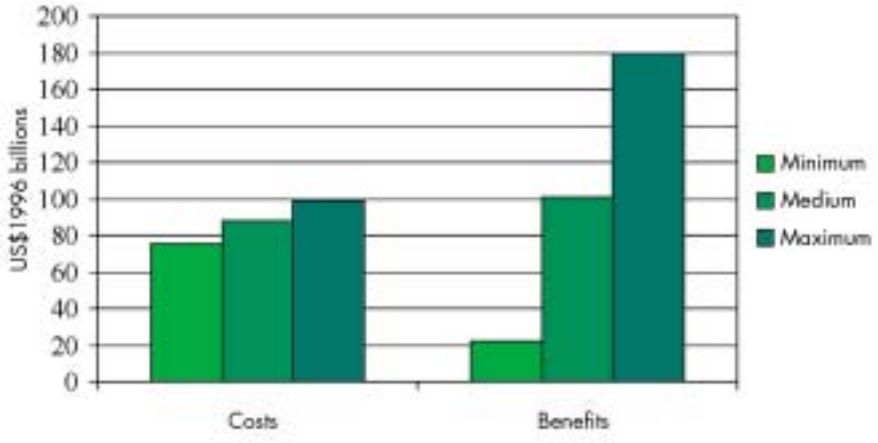
- There is no willingness to act on the conclusions of the cost-benefit analysis when this indicates that regulations do not fulfil the cost-benefit criterion.
- There is a tendency to rely uncritically on the cost-benefit estimates provided by the agencies in charge of each respective aspect of regulation without taking into account the fact that such estimates might potentially be biased.

- Costs and benefits are estimated overall without identifying who the "winners" and "losers" in each case, information which is of considerable political relevance.
- There is no sensitivity analysis which would reveal the extent to which the conclusions are dependent on specific methodological assumptions. Nor is there any discussion regarding the uncertainty surrounding the estimates used.

Figure 4 presents the overall results for the aggregate costs and benefits of environmental regulations passed by the federal government. These estimates are derived from an academic study (Hahn & Hird, 1991). The following observations can be made.

- There exists a considerable range of uncertainty surrounding the estimates, both for costs and benefits. However, the uncertainty range is greater for benefits than for costs. Indeed, the maximum benefit estimate is nine times higher than the minimum estimate.
- The range of cost estimates falls with the range of estimates for benefits. This implies that it is not possible to say whether the net benefit of regulation is positive or negative. Notwithstanding, if average cost is compared to average benefit, a positive net benefit is obtained.

Figure 4
Aggregate costs and benefits of federal environmental regulations



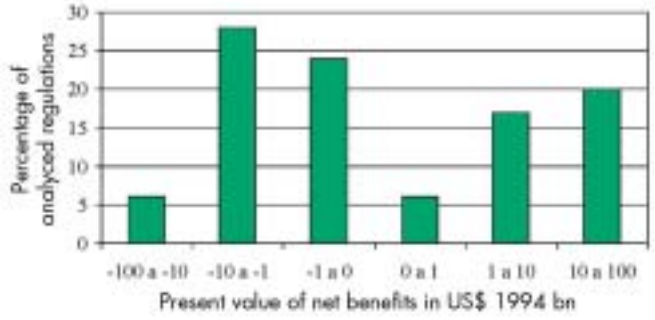
Source: Guasch & Hahnn, 1998.

It is interesting to compare the results from an independent study, like that of Hahn & Hird (1991) with the official estimates produced by the US EPA (Environmental Protection Agency). The EPA puts the cost of environmental regulations at US$54bn, which is significantly lower than the minimum cost of US$76bn estimated by Hahn & Hird. As regards benefits, EPA estimates benefits of US$1.450bn for air pollution regulations alone. This estimation is nearly 10 times higher than the maximum estimated by Hahn & Hird for all regulations put together.

Figure 5 presents results from an independent study of the cost-benefit balance for 54 federal environmental regulations. The horizontal axis represents various value ranges for the net benefit of each regulation ranges (that is benefits minus costs), while the vertical axis represents the number of regulations falling within each of these ranges.

The three columns on the right correspond to regulations whose benefits exceed their costs, and which are consequently justified from an economic viewpoint. These represent 43 % of the 54 regulations considered in the study. The net benefit of each of these regulations is relatively large, often in excess of US$10bn. The three columns on the left correspond to regulations whose costs exceed their benefits and which are therefore not justifiedfrom an economic viewpoint. These represent 57 % of the 54 regulations considered in the study. The net benefit of these regulations is relatively small, less than minus US$10bn in most cases. Summing net benefits across the 54 regulations, it is found that, overall, benefits exceed costs.

Figure 5
Net benefit of individual federal environmental regulations



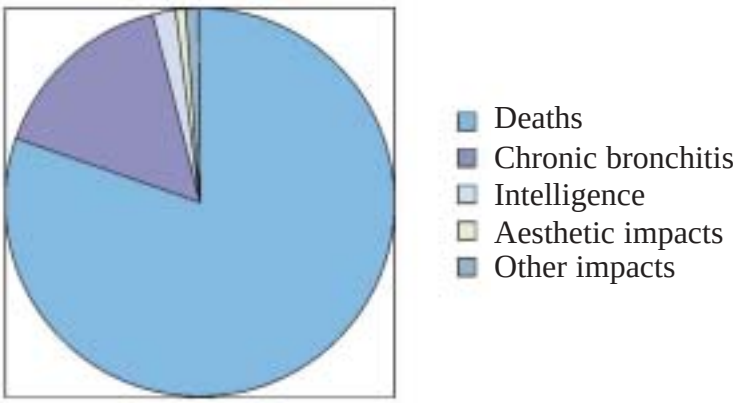
Source: Hahn, 1996

4.2. Cost-benefit analysis of the Clean Air Act

Perhaps the most ambitious environmental cost-benefit analysis carried out in the US was the study of the Clean Air Act 1970, a statute which controls the emission of air pollutants (EPA, 1997). It is estimated that between 1970 and 1990 the cost of complying with this statute reached US$523 bn.

As a result of these investments in pollution control equipment, important reductions in the concentrations of several important air pollutants have been achieved: 40 % for SO_2, 30 % for NO_x, 45 % for VOC, 50 % for CO, 90 % for lead and 15 % for ozone have been achieved. The study surveyed the the scientific literature to estimate the impact of these reductions on human health, and reviewed the economic literature to assess the value of these impacts. For example, each life saved was valued at US$4.8 m and each case of chronic bronchitis avoided was valued at US$260,000. Benefits were estimated totalling US$22.2 trillion, but with an ample range of uncertainty running between US$5,6 trillion and US$49,4 trillion. More than 80 % of the benefits are due to lives saved and another 16 % are due to the reduced incidence of chronic bronchitis (see Figure 6).

Figure 6
Breakdown of benefits estimated from the Clean Air Act



Source: EPA, 1997

The EPA study has been severely criticised for exaggerating the value of benefits, with results 17 times higher than those obtained by an independent study (Hahn & Hird, 1991). Indeed, estimated benefits for 1990 alone represent 20 % of the gross domestic product for that year. The main objections were that the study did not take into account:

- the fact that deaths tended to happen among people who were already close to death;
- the existence of a significant time lag between the occurrence of the pollution and its impact on health;
- the existence of considerable uncertainty about the health impacts of air pollution.

5. Experience with the Economic Model: the UK

In comparison with the US, economic analysis of environmental policies in Europe is still in its infancy. During the 1970s and 1980s, European Union (EU) Environmental Directives were primarily driven by scientific and political criteria, typically neglecting any kind of economic analysis.

From the 1990´s onward the situation started to change. The first sign of this was the Fifth Plan for EU Environmental Action, passed in 1992, which recognised that the economic assessment of environmental impacts might play an important role in attaining sustainable development. This was followed by the Maastricht Treaty, which incorporated in its Article 130r(3) the requirement the the EU study the costs and benefits of its actions or of its lack of action.

A recent study reviews the use of economic analysis in the formulation of EU environmental directives during the 1990´s (Pearce, 2000). The study found that numerous directives passed or reviewed in the middle of the decade made little or no use of economic analysis, however by the end of the decade this kind of analysis had become much more habitual.

Within the EU, the United Kingdom is one of the countries that has made most progress in the application of economic analysis to environmental policies. As a reaction to the increasing public interest in environmental issues

at the end of the 1980´s, the government appointed a renowned group of scholars to produce a statement on the matter. The resulting report entitled "Blueprint for a Green Economy" (and known informally as "The Pearce Report") has had great influence on the evolution of UK environmental policy and assured environmental economists an important role in that process. (Pearce et al., 1989).

"The Pearce Report" proposed, among other things, the application of economic analysis to environmental policy. Two years after its publication, in 1991, the Department of the Environment issued a document entitled "Policy Appraisal and the Environment" that presented some methodological guidelines for the economic analysis of environmental issues. However, these guidelines were only recommendations and did not represent statutory requirements.

Throughout the 1990´s, there was mounting political pressure to demonstrate that the benefits from environmental policies were large enough to justify their significant costs. In 1993, the requirement to estimate the cost of fulfilling all regulations that might have any impact on industry was introduced, a requirement which included EU environmental provisions. This tendency reached its climax in 1995 with the incorporation of an article into the new Environment Act that required the new Environment Agency to take into account the costs and benefits of its decisions.

5.1. The case of the water sector

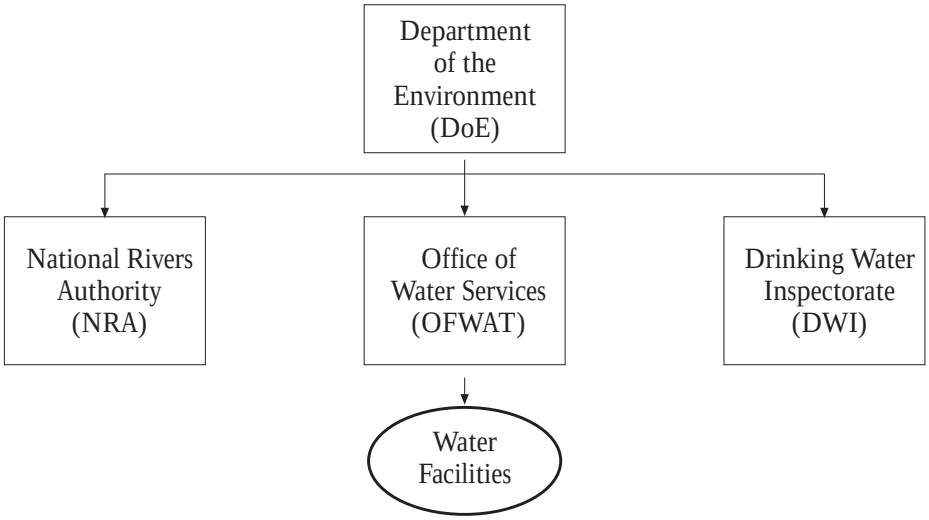
The water sector was probably the sector where the role of economics in environmental policy was most hotly debated in the UK. This can be attributed to two particular factors.

- First, the creation in 1989 of a new regulatory framework for the newly privatised water industry in England and Wales. This framework sets up three separate regulatory agencies: the Office of Water Services (OFWAT) which is responsible for setting water tariffs, the National Rivers Authority (NRA), and the Drinking Water Inspectorate (DWI) responsible for the control of river and drinking water quality respectively. This structure is shown in the Figure 7.

- Second, at about the same time, the issuing of a series of EU environmental directives on the quality of effluent to be returned to river or sea and on the quality of drinking water for human consumption.The first studies revealed that compliance with these directives would entail investments of the order of US$1,3bn to US$3,5bn. This wide range reflects the fact that the requirements of the directives can be interpreted more or less rigorously.

It was estimated that, depending on the exact investment, water tariffswould have to rise at between 1,5 % and 6,0 % per year in real terms.

Figure 7
Institutional framework of the water sector in England and Wales



In the absence of economic tools for comparing the costs and benefits of environmental regulations, a political debate arose between the economic regulator (who argued for a lax interpretation of the directives with a view to keeping tariffs low), and the environmental regulators (who argued for a strict interpretation of the directives in order to protect the environment). In the end, the economic regulator won the argument and the 1994 fee revision did not allow any tariff increase above 1,5 % in real terms.

As a result of this experience, an initiative was launched to develop a manual enabling the application of cost-benefit analysis to waste water treatment projects. All water sector agencies took part in the project, including the privatised water companies. The objective was to enable future differences of opinion between the economic and environmental regulators to be solved by means of the economic model rather than the political one.

The resulting "Benefit Assessment Manual" (Foundation for Water Research, 1997) contains a series of detailed methodological instructions covering all aspects of cost-benefit analysis. At the same time, the manual provides a review of all British literature on the environmental valuation of water quality, thereby creating a database of values that could be applied in future assessments.

The manual was used for the 1999 water tariff revision, and in this sense it served its purpose of providing an economic basis for environmental target setting in the water sector. However, the application of the manual turned out to be rather problematic for the following reasons.

- The lack of a culture of economic analysis background in the environmental regulatory bodies, together with the absence of qualified personnel to carry out the assessments. There was the feeling that cost-benefit analysis was too expensive and time-consuming, prompting a search for 'quick and dirty' shortcuts.
- There were relatively few existing valuation studies of water quality with which to construct the database of values, consequently users were forced to depend on the results of a very small number of studies meaning that the necessary numbers were not always available

5.2. Cost-benefit analysis of river quality

Maybe, the best way to explain the manual is by means of a particular illustration of the methodology applied to the evaluation of a number of possible alternative projects to improve the quality of the River Medlock, located in the North West of England (Tyson & Foster, 1996).

Pollution problems on the Medlock had arisen due to deficiencies at the local sewage works and the inadequacy of the combined sewer overflows. Due to the deficiencies in the sewage works, the quality of the river water was not good enough for fish to live in. While the deficiencies of the combined sewer overflow system caused aesthetic pollution, because sewage was directly discharged into the river when high rainfall occurred.

Three possible remedia projects were identified.

- *Project A:* which consists in the improvement of both the plant and the overflows.
- *Project B:* which involves only the improvement of the overflows.
- *Project C:* which involves onlythe improvement of the treatment plant.

Chart 5
Summary of alternative projects to improve the quality of the river Medlock

	Alternative Projects		
	A	B	C
Objective			
• Treatment works	3	no	3
• Combined sewer-overflows	3	3	no
Expense			
• Capital	£ 39,0 m	£ 35,0 m	£ 4.0 m
• Operational	£ 0,1 m	-	£ 0,1 m

Source: Tyson and Foster, 1996

As will be noted in chart 5, the improvement of the overflows is much more costly than the upgrading of the sewage works.

For the assessment of this type of projects, the manual suggests identifying the various communities of river users that may be affected by the intervention. In the Medlock case, three types of beneficiaries were identified.

- *Informal recreation:* i.e. people walking on the banks. These people benefit mainly from the aesthetic impact associated with the improvement of the combined sewer overflow. However, it is not likely they would benefit much from the water quality change brought about by the upgrading of t he sewage works. With a population of 11,000 people living near the river, it is estimated that there are likely to be around 240,000 recreational visits each year. The literature suggests a willingness to pay of £1.73 per person per visit to prevent the aesthetic impact brought about by the defective overflows.
- *Angling:* it is foreseen that the quality improvement of the sewage works discharge into the river will allow the development of a new coarse fishery, providing a benefit to anglers living in the region. the literature suggests there is a willingness to pay £ 6.20 for each angling visit.
- *Environmental conservation*: it was considered that the improvement of the river ecosystem would also be valued by those who do not use the river directly for recreational purposes. The environmental conservation was estimated at £1.37m based on earlier UK researcy. This benefit is much higher than that estimated for recreational uses.

Chart 6
Summary of benefits from improving the quality of the river Medlock

	Informal recreation	Angling	Consevation environmental
Impact	Aesthetic	New fishery	Ecosystem improvement
Affected population	11.000	30.000	
Yearly visits	240.000	12.000	
Benefit per visit	£ 1,73	£ 6,20	
Yearly benefit	£ 0,420 m	£ 0,073 m	£ 1,371 m

Source: Tyson and Foster, 1996

Adding up the flow of benefits and costs through time and discounting them according to their timing, the present value of costs and benefits is obtained (chart 6). The ratio of benefits to costs provides an indication of whether the project is economically viable. A value greater than one indicates that the project passess the economic test, whereas a value less than one indicates a failure.

Chart 7
Results of cost-benefit analysis for improving quality of the river Medlock

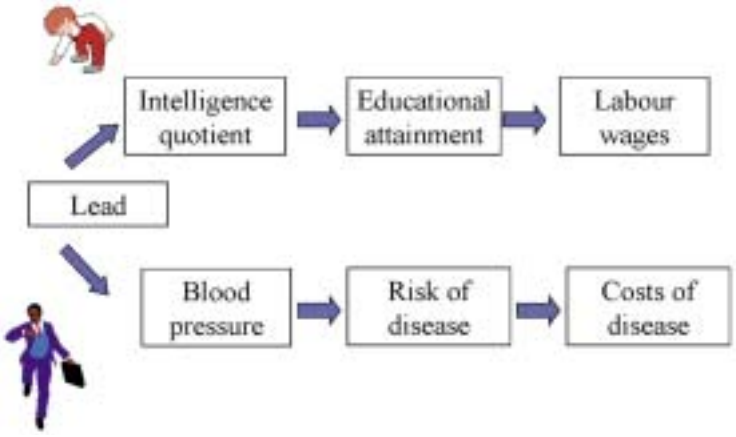
	Alternative Projects		
	A	B	C
Benefit-cost ratio at 5% discounting			
• Recreational benefits only	0,23	0,15	0,70
• Total benefits	0,84	0,15	4,98
Benefit-cost ratio at 6% discounting			
• Recreational benefits only	0,19	0,12	0,65
• Total benefits	0,72	0,12	4,58

Chart 7 shows the ratios of benefits to costs for various discount rates (5% versus 6 %), and also explores the impact of considering just the recreational benefits or also including the value of environmental conservation.

The results show that projects A and B can under no circumstances be justified as the ratios of benefits to costs are always below one. The reason is that the improvements to the combined sewer overflows are extremely costly in relation to the willingness to pay of those partaking in informal recreation, who are the main beneficiaries of the resulting aesthetic improvement.

On the other hand project C can be justified as long as the environmental conservation values are included, but cannot be justified in terms of the recreational benefits alone.

Figure 8
Impacts of lead in drinking water



5.3. Cost-benefit analysis of reduction of lead in drinking water

Another interesting UK example of the application of cost-benefit analysis to EU environmental directives is the review of the directive on drinking water quality, and in particular of the lead parameter that should be applied. The standard in the original directive was 50 mg/l. Notwithstanding, when the directive was reviewed it was proposed that the standard be reduced initially to 25 mg/l (in 2003), and eventually to the new limit recommended by the World Health Organisation of 10 mg/l in 2013. There was some discussion as to whether this new standard should be applied as a mean or a maximum. Due to the widespread use of lead, both in the public drinking water network and in household plumbing, the cost of meeting compliance with this new requirement would be particularly high for the UK (of the order of £1bn to £4bn).

Consequently, the drinking water regulator (DWI) commissioned a cost-benefit analysis of this standard in order to support the British position in the directive negotiations (OXERA, 1997).

The research identified two main groups of beneficiaries from the new standard.

- Children, whose intellectual development may be affected by lead consumed in drinking water.

- Middle aged men, who may suffer rising blood pressure as a result of lead consumption, bringing about an increased risk of heart attacks and hypertension.

Chart 8
Impact of a one point change in IQ on expected earnings

Effect	Direct Impact	Indirect Impact	Total Impact
Wages			
• Minimum	0.6%	(0.1*3.5%)	1.0%
• Maximum	1.3%	(0.1*6.6%)	2.0%
Probability of working	0.3%	(0.1*1.6%)	0.5%

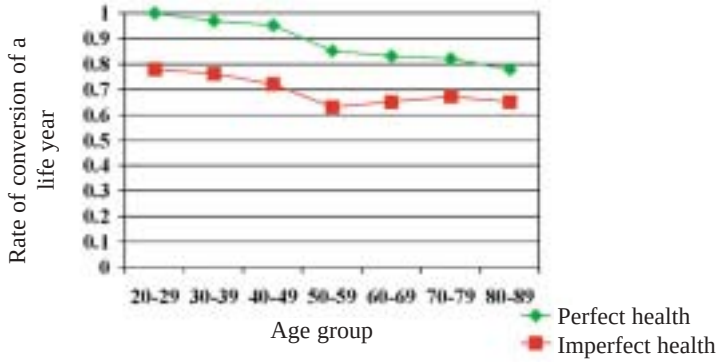
Fonte: OXERA, 1997

The following methodology was adopted in order to assess the benefits for children.

- The first step is to estimate the relationship between lead consumption and IQ in children. A review of the scientific literature shows that an increase from 10 mg/dl to 20 mg/dl of lead in the bloodstream reduces the intelligence quotient by two points. However, what is much more difficult is to trace out the relation between lead absorbed from drinking water and the concentration of lead in the bloodstream. One reason for this difficulty is that baseline levels of lead concentration in the blood have declined significantly during the last decades due to the success of other policies for reducing environmental exposure to particularly the phasing out of lead in petrol.
- The second step is to estimate to what extent children's future wages are dependent on their IQ. The reduction in IQ due to lead absorption has a direct impact on future salary and probability of employment, and also an indirect impact via its effect on educational attainment. Two people with the same educational attainment may obtain different salaries due to differences in their IQ, moreover people with lower IQ usually reach lower levels of educational attainment.

- The final step in the evaluation of this benefit is to multiply the change of lead concentration in the bloodstream by the expected salary level and by the expected percentage change in salary due to the IQ effect.

Figure 9
Relative value of a life year at different ages and in different health states



Source: OXERA, 1997

For assessing the benefits to middle aged men the following methodology was adopted:

- The first step was to establish the relationship between lead consumption, blood pressure and cardiovascular diseases. According to the scientific literature, an increase in the concentration of lead in the bloodstream from 5 mg/dl to 10 mg/dl would raise blood pressure by about 1 mm Hg. The implication is that a reduction of the lead limit for drinking water would reduce the risk of cardiovascular diseases by about 0.1 %.
- The second step is to estimate the costs of this disease. These include treatment costs, premature death and morbidity effects which reduce the quality of life of survivors. The quantification of medical costs is straightforward enough. However, valuing the human mortality and morbidity effects is more complex; thus, two alternative methods are used.
- *Income loss.* Under this approach deaths and diseases are valued according to the income lost by those affected as a result of being unable to work.

- *Willingness to pay.* Under this approach deaths and diseases are first converted into units of quality adjusted life years lost as a result. This is done using the conversion rates illustrated in the Figure 9, which permit the conversion of a perfect health year to an imperfect health year at different ages. Thus, for example, a person who has a heart attack at 60 but survives until the age of 80 in imperfect health loses a number of quality adjusted life years equivalent to the area between the lower and upper curve between the ages of 60 and 80. Using a £ 2 m value of life, and assuming that each person who dies on average loses 31 years of life, a value of £ 64.200 per life year is obtained. This figure is multiplied by the number of lost quality adjusted life years in order to obtain the monetary value of the disease.

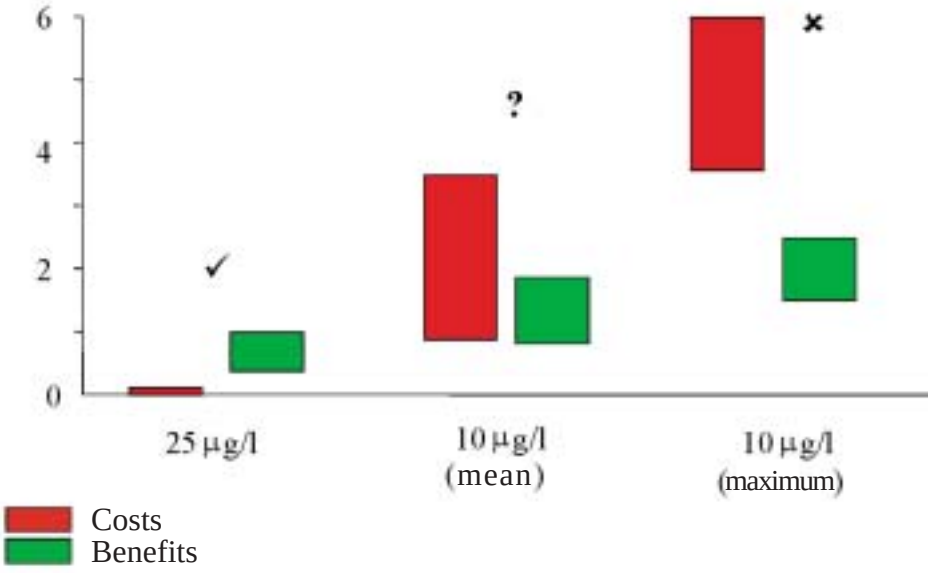
It is important to note that both benefit categories are assessed in an incremental manner relative to what would have happened anyway in the absence of the directive. In the UK, 1 % of the water distribution piping is renewed every year. Thus the level of lead in drinking water would decrease gradually over time even in the absence of the directive. The principal effect of the directive is simply to accelerate the pace of this natural process.

To the benefits described above must be added certain others related to the management of drinking water distribution systems. In particular, lead pipe substitution could be expected to reduce treatment costs and water losses in the distribution system. Notwithstanding, these benefits represent only 10 % of the total, compared with the impact on children's intelligence which represents more than two thirds of the total.

Regarding costs, there was a wide range of estimates due to the difficulty of knowing whether the requirements of the directive might be met simply by altering the water treatment process, or whether a complete substitution of the lead piping would be necessary. The minimum cost estimate is that associated with a treatment only solution, while the maximum level is that associated with the full replacement of lead pipes.

Figure 10 below presents the results of the analysis. The proposed temporary standard of 25 mg/l is clearly justified according to the balance of costs and benefits. The results for the average standard of 10 mg/l are ambiguous. The range of possible benefits falls within the range of possible costs. The standard of 10 mg/l as a maximum is clearly not justified.

Figure 10
Results of the cost-benefit analysis for the reduction of lead in drinking water



Source: OXERA, 1997

6. Mechanisms for establishing the economic model

Having reviewed the US, EU and UK experiences in the application of economics to environmental decision making, it is interesting to ask: Which are the factors which have most contributed towards the successful implementation of the economic model?

On the basis of the previous discussion, it is possible to identify four factors which have been particularly important in supporting the use of economics in policy formulation.

- First, the need of judicial support. In all the cases studied, economic analysis was not taken seriously until it was made a statutory obligation. Until that point, guidelines and exhortations had little practical effect.
- Second, the importance of an adequate institutional framework. The entity in charge of performing economic analysis of environmental

policies must have both the technical capacity and the political autonomy to produce credible results.

- Third, methodological guidelines for economic analysis can be very helpful. The reason is that they permit the standardisation of the analysis, which is essential for facilitating comparisons between alternative policies. They also help to ensure a minimum level of quality for economic analysis.

- Fourth, the importance of the academic community. Environmental economists in the UK played a key role in promoting the use of economic tools by policymakers, and were directly incorporated into the decision making process by the creation of academic advisory panels. In the US, the academic community also plays an important role, by providing a critique of official cost-benefit studies as well as an alternative independent source of information on environmental costs and benefits.

The discussion has shown that the economic model offers many useful tools for the evaluation of environmental policies. These techniques help to clarify the cost of regulations, and their relative efficiency in obtaining environmental results. In the absence of this type of analysis, there can be no certainty that these policies represent a net benefit to society.

The case studies presented in this paper confirm that the US continues to be in the lead when it comes to applying economic analysis to environmental problems. It is the only country that has succeeded in conducting global economic evaluations of environmental regulations. However, in Europe, increasing emphasis is being placed on economic assessments, as is amply illustrated by the UK experience.

Nonetheless, even in the countries where the economic model has been adopted with greatest enthusiasm, its impact on actual environmental decisions has often been less than might have been anticipated. In reality, as noted from the outset the economic perspective represents one view among many of environmental decision making. It can never entirely replace the political, scientific or environmental models, but rather provides a complement to them.

The discussion concludes with a quotation from Professor David Pearce, who was largely responsible for the greater incorporation of economic criteria into environmental decisions in the UK. During his long years of experience in this field, he has acquired a very realistic understanding of the influence that economists can have in the political arena. Thus, he says:

> *"If decisions were rational and efficiency was our only objective, then economic analysis would have a great deal of influence. However, decisions are not rational and efficiency is not our only objective. Therefore it would be surprising if economic analysis had a great deal of influence."*
>
> (Pearce, 2000a).

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